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The Effect of Storage on the Composition and Nutritive Properties of Farm-Style Hams[a]

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The results obtained in an investigation of the composition, nutritive value and keeping quality of hams dry cured with salt only are presented. The hams were cured and smoked and then stored at 40°, 70°, and 90° F., for 6 weeks, and 6 and 12 month periods. Data obtained on weight losses, chemical constituents, nitrogen efficiency value, vitamin content, palatability, and bacteriological flora are discussed.

The present article, one of a series *(4, 5, 6, 14)*, deals further with the relation of processing to the quality of cured hams. Approximately 2 billion pounds of meat are used annually by farmers, much of which is cured or otherwise processed on the farm.

Although there is some scattered information *(2, 8, 10, 12)* available regarding farm curing methods and ham composition, more complete data are needed on the composition and the effect of aging of farm-style hams. As previously reported *(4)*, 74% of farmers who cure meat employ dry curing without pumping. Approximately one-half of this group use only salt as a curing agent. Experiments herein reported were conducted to obtain information on this type of unpumped dry salt-cured ham.

In the present work, this commonly practiced method of dry-curing hams with salt only, was duplicated under controlled experimental conditions using meats from animals of known history and feeding. Samples were analyzed to determine chemical composition, nitrogen efficiency value, vitamin content, palatability, and bacterial content. Following publication of the present paper on hams dry-cured with salt only, a later paper is planned to present data obtained on other methods of farm curing. Information obtained from these studies provides a basis for modifying methods to effect improvement in the quality of farm cured hams.

EXPERIMENTAL

One hundred and eight hams selected for the study were obtained from hogs of known history ("Record-of-Performance"), all receiving the same type of feed. The trimmed hams, prior to curing, averaged 15 pounds, 9 ounces; ± 15 ounces. The hams were thoroughly rubbed with table salt, using 4 pounds per 100 pounds of meat, and stored overnight at 38° F. (3.3° C.). They were again rubbed, using 6 pounds salt per 100 pounds of meat, and placed skin side down in wooden bins perforated to allow drainage. Since only a relatively small amount of salt adhered to the meat after rubbing, the remainder was carefully packed around the hams, particularly on the lean exposed surfaces and bone areas. The hams were cured for approximately 23 days (1½ days per lb.) at 38° F. (3.3° C.). When the curing was completed, the hams were spray-washed for 3 minutes in water at 110° F. (43.3° C. to remove surface salt, hung up to dry, and then smoked 42 hours (6 hours daily) in hickory smoke at 150° F. (65.6° C.) to an internal temperature of 125°-130° F. (51.7°-54.4° C.). The hams were refrigerated at 38° F. (3.3° C.) after each daily 6-hour period of smoking. The average weight of these smoked hams was 13 pounds, 12 ounces; ± 14 ounces.

The smoked hams were then divided into 3 lots for storage at 40°, 70°, and 90° F. (4.4°, 21.1°, and 32.2° C.). Samples were withdrawn for analyses after 6 weeks, and 6 to 12 months. During storage, the temperatures of the hams were determined with thermocouples inserted into the center of the meat. Temperatures were recorded on strip charts with two 16-point automatic potentiometers. The average relative humidities during storage at 40°, 70°, and 90° F. (4.4°, 21.1°, and 32.2° C.) were. respectively, 90, 75, and 55%. Weights of the fresh, cured, smoked, and stored hams were obtained as a basis for calculating losses in processing and storage. The conditions used in storing the hams were for experimental evaluation, storage at the constant temperatures of 70° and 90° F. (21.1° and 32.2° C.) being more drastic than actual farm practice, but useful to accelerate aging processes.

Table 1 shows the changes in weight, in terms of both pounds and percentages, that occurred in 97 hams during processing and storage. Losses of weight were of course mainly caused by evaporation of moisture. The loss of 2.6% which occurred during curing, was followed by a further loss during smoking, resulting in a total processing loss of 11.5%. The data show that on storage, loss of moisture due to temperature and humidity differences occurred more slowly at 40° F. (4.4° C.) than at 70° F. (21.1° C.) or 90° F. (32.2° C.). After 12 months' storage, moisture losses at 70° and 90° F. (21.1° and 32.2° C.) were respectively only 2.5 and 1.9% more than after 6 months' storage.

TABLE 1

Average weights of farm cured hams at different stages of processing and storage

Description of hams	Storage[1] conditions	No. of hams	Weight	Weight in relation to fresh weight
			lb.	*%*
Fresh	.....	97	15.6	100.0
Cured	.....	97	15.2	97.4
Cured and smoked	.....	97	13.8	88.5
Stored	6 wks., 40° F.	15	13.1	84.0
	6 wks., 70° F.	16	12.8	82.1
	6 wks., 90° F.	17	12.5	80.1
	6 mos., 40° F.	5	12.7	81.4
	6 mos., 70° F.	10	12.0	76.9
	6 mos., 90° F.	6	11.4	73.1
	12 mos., 40° F.	6	12.0	76.9
	12 mos., 70° F.	7	11.6	74.4
	12 mos., 90° F.	8	11.1	71.2

[1] Relative humidities at 40°, 70°, and 90° F., were 90, 75 and 55%, respectively.

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CHEMICAL COMPOSITION

Proximate composition, soluble nitrogen, nonprotein nitrogen, free fatty acids, peroxide value, sodium chloride, and pH were determined on representative samples from 21 cured and stored hams and 5 fresh hams, using the methods of analysis described in a previous paper *(6)*. Chlorides are reported in terms of percentage of sodium chloride. Results for nitrogen were calculated as percentage of total nitrogen. The percentage of free fatty acids was expressed as oleic acid content of the fat and the peroxide value as milliequivalents per 1000 g. of fat. The average results of the analyses are shown in Table 2. Variation in salt content was subjected to statistical analysis. In these calculations, the salt content of all the stored cured and smoked hams was adjusted to that which would be present if the hams contained 65.1% moisture, this being the moisture content of the hams prior to storage. After making these adjustments, the mean salt content was found to be 4.39% with a standard deviation of ± 0.91%. The relatively large standard deviation indicates that these dry-cured hams varied considerably with respect to salt content. Based on this fact, it appears that study is needed to develop a curing technique which produces hams of less variable salt content.

As shown in Table 2, the protein, fat, ash, and sodium chloride content of the hams increased to the degree that the hams became dehydrated during storage. To aid in the detection of protein changes, the data showing the content of soluble and nonprotein nitrogenous compounds were adjusted to correspond to those of hams with the moisture content of unstored cured and smoked products (65.1%). With the exception of the increased amounts of nitrogenous materials which occurred in the ham stored 12 months at 90° F. (32.2° C.), no significance was attached to differences at the other storage temperatures. The only appreciable increase in free fatty acids occurred in 12 months at 70° and 90° F. (21.1° and 32.2° C.). The peroxide content was relatively low in all samples. Since rancidity was detected organoleptically in some aged samples, the general belief, that the peroxide value is a poor index of rancidity, was reaffirmed. The range of average pH values, 6.13 to 6.78, was narrow, and in general pH varied but little during processing and storage. The relatively higher pH values of 6.46 and 6.78 of hams stored at 70° and 90° F. (21.1° and 32.2° C.) for a period of 12 months probably can be attributed to the effects of proteolysis. The results indicate that storage produced dehydration which was inversely related to time and temperature. Significant proteolysis occurred only at 90° F. (32.2° C.), whereas marked fat hydrolysis occurred at both 70° and 90° F. (21.1° and 32.2° C.) during 12 months' storage.

NITROGEN EFFICIENCY VALUE

Samples were prepared by a previously described method *(5)*. Diets were made up and fed to rats essentially as previously described by Hoagland and coworkers *(7)*. Since the sodium chloride content of different lots of hams varied, each diet was adjusted to 3.15% salt. The average gain in weight in 30 days of 8 albino male rats per gram of nitrogen consumed was considered the nitrogen efficiency value (Table 3).

TABLE 2

Chemical analyses of cured and stored farm-style hams

Description of hams	Storage conditions	No. of hams	Moisture	Protein (N x 6.25)	Fat	Ash	Sodium chloride	Soluble nitrogen	Non-protein nitrogen	Free fatty acid (as oleic acid)	Peroxide value m.e.q. per 1000 g.	pH
			%	%	%	%	%	%	%	%	%	
Fresh	.....	5	74.5	21.6	3.01	1.13	0.06	30.3	13.1	(0.37-0.73)[2] 0.56	1.11	6.01
Cured and smoked	.....	4	65.1	24.1	6.42	5.08	4.30	20.2	16.3	(0.83-2.82) 1.41	0.74	6.45
Stored	6 wks., 40° F.	4	62.6	25.9	5.88	5.58	4.48	18.9 (18.2)[1]	17.3 (16.6)	(0.66-1.98) 1.35	1.52	6.13
	6 wks., 70° F.	3	61.3	26.1	6.85	5.89	5.26	18.7 (17.6)	16.5 (15.5)	(0.97-1.66) 1.20	1.32	6.20
	6 wks., 90° F.	3	61.6	27.1	6.15	6.23	5.46	20.3 (19.2)	17.3 (16.4)	(1.21-1.69) 1.37	0.87	6.30
	6 mos., 40° F.	1	61.5	27.2	3.43	6.54	6.65	19.1 (18.0)	15.3 (14.5)	1.27	5.71	6.38
	6 mos., 70° F.	2	57.3	30.4	5.80	7.57	6.69	20.5 (17.0)	17.4 (15.3)	(1.02-3.42) 2.22	1.95	6.18
	6 mos., 90° F.	1	47.8	34.3	8.93	9.30	8.74	24.1 (17.7)	23.4 (17.2)	0.72	6.55	6.18
	12 mos., 40° F.	1	54.6	31.4	4.89	9.66	8.70	19.6 (16.4)	16.4 (13.8)	2.70	6.37	6.25
	12 mos., 70° F.	1	53.5	31.8	5.87	9.46	8.75	25.4 (20.8)	20.6 (16.9)	3.92	2.38	6.46
	12 mos., 90° F.	1	43.7	37.1	9.13	9.27	9.15	37.5 (25.2)	35.2 (23.6)	11.60	4.62	6.78

[1] Figure in parentheses "( )" adjusted to show content in hams whose moisture content corresponds to that of the original cured and smoked hams (65.1%).

[2] Figures in parentheses "( )" show range of free fatty acid content.

TABLE 3

Nitrogen efficiency values of cured and stored farm-style hams [1]

Description of hams	Storage conditions	No. of hams [2]	Gain and intake in 30 days				
			Gain in weight	Feed consumed	Nitrogen consumed	Feed per gram gain in weight	Gain per gram of nitrogen
			g.	g.	g.	g.	g.
Fresh	.....	4	90	280	4.480	3.11	20.09
Stored	6 wks., 40° F.	10	112	323	5.168	2.88	21.67
	6 wks., 70° F.	10	110	320	5.120	2.91	21.48
	6 wks., 90° F.	10	99	300	4.800	3.03	20.62
	6 mos., 40° F.	3	116	333	5.328	2.87	21.77
	6 mos., 70° F.	6	122	341	5.456	2.80	22.36
	6 mos., 90° F.	4	104	318	5.088	3.06	20.44
	12 mos., 40° F.	4	127	355	5.680	2.80	22.36
	12 mos., 70° F.	5	131	358	5.728	2.73	22.87
	12 mos., 90° F.	6	107	326	5.216	3.05	20.51

[1] Average gain in weight of 8 male rats in 30 days.
[2] A minimum of 3 hams were required per determination.

When the results on the fresh hams—20.1 g. gain per g. of nitrogen consumed—were used as a basis for comparison, storage of hams produced no detrimental effects upon the nitrogen efficiency value.

VITAMIN CONTENT

For vitamin analyses, a sample representative of the entire lean portion of each ham was prepared by grinding the tissue three times through a fine food chopper with careful mixing after each grinding. Thiamine and riboflavin determinations were carried out simultaneously on the same extract, by fluorometric methods; and niacin was determined microbiologically. The methods for the 3 vitamins were essentially similar to those described by the Association of Vitamin Chemists *(1)*. Results are shown in Table 4.

In interpreting the data in Table 4, it must be recognized that the vitamin content of hams varies widely, and that the vitamin content of original individual hams could not be determined under the conditions of the experiments. The vitamin values ranged greatly among the groups. In the case of thiamine, the content ranged from 11.0 to 29.9 γ per g. of protein; riboflavin 7.6 to 11.0 γ; and niacin 99.4 to 152.3 γ. Similarly, large variations have been reported in the literature with respect to the vitamin content of fresh and cured pork. Schweigert, McIntire, and Elvehjem *(11)* showed variations of thiamine, riboflavin, and niacin content from 33.9 to 51.4; 12.8 to 16.5; and 122 to 163 γ per g. of protein, respectively. McIntire and coworkers *(9)*, in a study of fresh and cooked pork, reported that the thiamine content ranged from 7.4 to 15.2; riboflavin from 1.6 to 3.0; and niacin from 31 to 49 γ per g. of fresh loin. Vail and Westerman *(13)* found a wide variation in thiamine content among cuts from the same picnic ranging from 18.5 to 32.4 γ per g. on a moisture-free basis. In the case of cuts from another picnic obtained from another carcass, the range was from 23.1 to 44.1. Dann and Handler *(3)* reported that the niacin content of fresh pork muscle varied from 41 to 102 γ per g.

Since lean fresh pork is an excellent source of thiamine, riboflavin, and niacin, any changes that took place in the vitamin content during the processing and storage periods are of particular interest. From inspection of the data in Table 4, the apparent loss of thiamine during curing was 3.2 γ (10.7%) with further losses during storage ranging from 4.4 to 15.7 γ (16.4 to 58.8%). In the case of the riboflavin and niacin, the data show that there were apparent gains which are assumed to mainly reflect variation between samples. These data indicate that no deterioration of riboflavin and niacin occurred, and are substantially in agreement with the results of Schweigert *et al. (11)* who reported recovery of thiamine, riboflavin, and niacin of 85, 104, and 106%, respectively, from cured hams.

Including samples stored for lengthy periods at high temperatures, all the hams were an excellent source of riboflavin and niacin—and thiamine as well. The content of thiamine, however, was reduced during processing and storage.

TABLE 4

Average vitamin content of cured and stored farm-style hams

Description of hams	Storage conditions	No. of hams	Thiamine		Riboflavin		Niacin	
			S [1]	P [2]	S	P	S	P
Fresh	.....	3	6.5	29.9	1.6	7.6	23.1	107.1
Cured and smoked	.....	3	6.4	26.7	2.3	9.7	24.0	99.4
Stored	6 wks., 40° F.	3	5.5	21.4	2.8	11.0	32.8	126.7
	6 wks., 70° F.	3	5.4	20.8	2.7	10.5	28.9	110.7
	6 wks., 90° F.	3	5.1	18.9	2.8	10.3	33.2	122.4
	6 mos., 40° F.	1	5.6	20.7	2.7	10.0	40.0	145.8
	6 mos., 70° F.	2	5.9	19.5	2.7	8.9	46.3	152.3
	6 mos., 90° F.	1	7.6	22.3	3.7	8.4	39.2	114.2
	12 mos., 40° F.	1	5.4	17.1	3.0	9.5	41.3	131.7
	12 mos., 70° F.	1	4.5	14.2	2.7	8.4	43.8	137.9
	12 mos., 90° F.	1	4.1	11.0	2.9	7.8	40.6	109.4

[1] Values in micrograms per gram of sample.
[2] Values in micrograms per gram protein.

ORGANOLEPTIC ANALYSES

The hams were prepared for taste testing in a manner similar to that previously employed in testing commercially-cured hams *(14)*, using a 1-to-5-point score sheet, with descriptive adjectives as indicated below:

Score	Intensity	Desirability
1	Imperceptible	Undesirable
2	Perceptible	Acceptable
3	Slightly pronounced	Slightly desirable
4	Moderately pronounced	Desirable
5	Pronounced	Very desirable

Judgments were made by a panel composed of from 8 to 10 experienced taste testers, on the desirability and intensity of the lean and fat tissues of the various hams. Color, tenderness, juiciness, and the degree of saltiness of the lean portion were also judged.

With respect to the keeping quality of these stored products, the following was observed: Of 6 hams stored at 40° F. (4.4° C.), 3 out of 4 tested after 6 weeks' storage were found to be desirable; one tested after 6 months' storage was found to be sound; and the remaining ham when tested after 12 months' storage was also palatable. Of 7 hams stored at 70° F. (21.1° C.), one out of 4 tested after 6 weeks, one of 2 tested after 6 months, and the remaining ham stored 12 months, were found to be undesirable. Of 5 hams stored at 90° F. (32.2° C.), one of 3 tested after 6 weeks, one after 6 months, and the other after 12 months, were found to be undesirable. The undesirable flavors which developed during storage were characterized as moldy, cheesy, musty, or rancid. Hams stored at 40° F. (4.4° C.) aged slightly but remained edible after 12 months' storage. Products stored at 70° F. (21.1° C.) were appreciably deteriorated if stored 6 months or longer; advanced deterioration occurred in those stored at 90° F. (32.2° C.) for 6 months. As previously noted, storage at temperatures constantly maintained at 70° and 90° F. (21.1° and 32.2° C.) was considerably more drastic than normal storage on farms; consequently, these data do not directly indicate the normal keeping quality of this type of ham.

BACTERIAL CONTENT

Bacteriological counts were made by a previously reported method *(5)* on samples of the same hams used for chemical analyses. Results were reported as numbers of organisms per gram of meat. A value of less than 1000 bacteria per gram has been arbitrarily accepted as an insignificant number of bacteria.

Twenty-six samples were examined, of which 19 had less than 1000 bacteria per gram. Five fresh and 4 freshly cured and smoked samples also had an insignificant count. Four samples stored 6 weeks at 40° F. (4.4° C.) had less than 1000 bacteria per gram. Of 3 samples stored 6 weeks at 70° F. (21.1° C.), two were found to have an insignificant count, and the remaining ham had an unexplained estimated count of 30 million organisms. Three hams stored for 6 weeks at 90° F. (32.2° C.) were found to have less than 1000 bacteria per gram.

After 6 months' storage a ham held at 40° F. (4.4° C.) had an insignificant count; two hams held at 70° F. (21.1° C.) also had an insignificant count; and a ham stored at 90° F. (32.2° C.) had a count of 290,000 organisms. Three hams stored for 12 months respectively at 40°, 70°, and 90° F. (4.4°, 21.1°, 32.2° C.), contained 135,000, less than 1,000, and 1,030 bacteria per gram. A majority of the bacteria in the hams were non-pathogenic micrococci, and none was found to be anaerobic.

These results indicate that this method of farm curing generally produces hams which are wholesome from the standpoint of both numbers and types of bacteria and not ordinarily subject to bacterial spoilage on storage. There was no apparent correlation between bacterial counts and storage conditions. Since the contrary was true in the case of palatability scores, the data suggest that bacterial contamination was not the decisive factor in determining the storage life of the hams.

SUMMARY AND CONCLUSION

A study was conducted to provide data on the composition, nutritive value, and the effects of storage on hams dry cured with salt only. The hams were cured and smoked and stored at 40°, 70°, and 90° F. (4.4°, 21.1°, and 32.2° C.), for 6 weeks, and 6-and-12 month periods. Data were obtained on weight losses, chemical constituents, nitrogen efficiency values, vitamin content, palatability, and bacteriological flora.

The results showed that an average weight loss of 11.5% occurred during processing. Appreciable weight losses occurred during storage; these depended on time, temperature, and relative humidity. It was shown through a statistical analysis that the salt content of farm-style hams varied widely, indicating a need for a technique to produce a more uniform product.

The content of protein, fat, ash, and sodium chloride increased to the degree that hams became dehydrated during storage. During storage, appreciable increases in amounts of soluble and nonprotein nitrogenous compounds occurred only in a sample stored at 90° F. (32.2° C.) for 12 months, in which some protein degradation presumably occurred. An appreciable amount of fat hydrolysis occurred in hams stored for 12 months at 70° and 90° F. (21.1° and 32.2° C.).

The processing and storage of the hams had no detrimental effects upon the nitrogen efficiency value.

No deterioration of riboflavin and niacin occurred during processing and storage, but a reduction in the thiamine content of the hams was observed.

Hams stored at 40° F. (4.4° C.) aged slightly during 12 months' storage; those stored at 70° F. (21.1° C.) deteriorated appreciably on storage of 6 months or longer, while those stored at 90° F. (32.2° C.) were scored *undesirable* after 6 months' storage.

The hams were in general wholesome from the standpoint of numbers and types of bacteria. Based on the data, it was concluded that bacterial contamination was not the decisive factor in determining the edible storage life of the hams.

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